



The Relationship Between Sugar-Sweetened Beverages, Takeaway Dietary Pattern, and Psychological and Behavioral Problems Among Children and Adolescents in China

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Background and Aim: The association of sugar-sweetened beverage (SSB) consumption and takeaway dietary pattern with psychological problems in Chinese children and adolescents has not been concretely reported. Our study aimed to investigate the association between SSB consumption, takeaway dietary pattern, and psychological and behavioral problems (PBPs).

Methods: Cluster sampling method has been adopted from April to May 2019 to conduct a questionnaire survey among 30,188 children and adolescents in grades 1 to 12 from 14 schools in six streets in Bao'an District of Shenzhen. This cross-sectional study investigated the association of consumption of SSBs and takeaway patterns with PBPs, and PBPs were measured by the Strengths and Difficulties Questionnaire (SDQ) in primary, junior, and senior high school students.

Results: A total of 33,801 primary, junior, and senior high school students (mean age = 12.44, SD = 3.47) ranging from 6 to 18 years old were recruited in this study using a health survey of children and adolescents in junior and senior high schools (grades 1–12), and 30,188 students with no missing data were finally analyzed (questionnaires with missing value >5% were excluded). The top three SSBs in the intake frequency were milk beverage drinks (not milk), vegetable protein drinks, and fruit and vegetable juice drinks. Adjusted for demographic factors, the higher the frequency of students consuming SSBs who have significantly higher PBPs, the higher the frequency of students with takeaway dietary patterns who also have significantly higher PBPs. More frequent intake of SSBs [odds ratio (OR) = 2.23, 95%CI = 2.0–2.47, $p < 0.01$] and higher takeaway dietary patterns (OR = 2.34, 95%CI = 1.81–3.03, $p < 0.01$) were associated with higher SDQ total difficulties scores. When low and medium consumption of SSB was compared, children and adolescents who have high SSB intake were more associated

with total difficulties score (OR = 3.10, 95%CI = 2.67–3.59, $p < 0.01$), and when low and medium takeaway dietary patterns were compared, children and adolescents who have high takeaway dietary patterns were more associated with total difficulties score. The joint associations of SSBs and takeaway pattern with SDQ were stronger than the associations individually.

Conclusions: Students consuming higher SSBs and having takeaway dietary pattern are associated with increased levels of PBPs individually and interactively. These results may have implications for mental health prevention in adolescents.

Keywords: sugar-sweetened beverages, take-away dietary patterns, strengths and difficulties questionnaire, children, adolescents, psychological and behavioral problems

INTRODUCTION

Throughout the past few decades, sugar-sweetened beverages (SSBs) account for most of the growth in global sugar consumption (1–3). In a previous study, we found that SSBs and foods with high sugar contents may cause obesity and carious disease, may stimulate chronic diseases, may also activate hyperactivity disorders (4) and obesity-related type 2 diabetes mellitus, cancers, metabolic syndrome, and cardiovascular disease (5, 6). Additionally, SSBs also contain other additives that could cause children's behavioral problems and obesity (7–10). As we have known, common daily SSBs include carbonated and fizzy drinks, sweetened milk and milky tea drinks, sparkling water, energy drinks, sweetened orange fruit drinks, sports and energy drinks, vitamin-water drinks, and vegetable protein drink (10–13). The 2015 Dietary Guidelines for Americans recommends limiting total added sugar intake to <10% of daily calories (14). Therefore, a series of problems caused by SSBs should also be noted.

It is worth noting that the impacts of SSBs on mental health have attracted widespread interest from researchers. Previous evidence suggests that the increase in sugar drinks consumption is thought to be a predictor and a result of mental health problems (15). A cross-sectional study explored the association between soft drinks, and hyperactivity and behavioral problems in adolescents (16). And we also have found in Australia that there is a correlation between the consumption of sugar drink and passively acquired mental health problems among adolescents (17). Some others also indicated similar results such as sugar consumption have being linked to an increased risk of attention deficit/hyperactivity disorder (ADHD), depression, and anxiety symptoms (13, 16–18). These results almost suggest that SSBs may have adverse effects on the mental health susceptibility of adolescents (19). These beverages should be consumed with caution, not only because excessive sugar intake can lead to an imbalance in caloric intake that affects a balanced diet but also because it may be associated with mental health problems (20–22), especially among school-aged children.

Previous studies have also shown that the proportion of food spending on eating out of home in Chinese cities rose from 7.9% in 1992 to 21.2% in 2010 (23), which is consistent with a longitudinal study with data collected from the China Health

and Nutrition Survey, which found that eating away from home became more common (24). The tempo of life is becoming faster, more and more people also will chose convenient lifestyles, and one of the most obvious characteristics of fast foods and takeaway foods is comfort, which means they save extra time greatly (25, 26). However, in one longitudinal study, researches have found the associations between fast food and physical health (27, 28). Even so, with the rapid development of the economy, more and more electrical products appear in front of us. Many people are ordering fast food takeout online via electronic products (e.g., automobile phone) and ordering food at home (takeaway, takeout, and fast food), which has become more and more popular in the recent decades. These all belonged to unhealthy diet patterns (UDPs). Fast-food consumption is significantly and positively associated with total energy, total fat, saturated fat, total carbohydrate, added sugars, SSBs, and non-beverage energy density. The consumption of fast food and takeaway food represents a public health problem and has been found to be associated with overweight and poor diet quality, as these fast-food and takeaway food menus often contain foods high in energy and fat/sugar (29, 30). More than that, some studies have found significant independent associations between the takeaway dietary patterns and sweet and fast foods and the prevalence of mental health (31–35). For adolescents, a review of nine cohort and three cross-sectional studies confirmed the association between unhealthy diets (including fast food and takeaways) and an increased risk of mental illness (36).

Previous researches exactly reported the relationships between SSBs and takeaway dietary patterns (25, 37, 38). Relative fast-food and takeaway environment exposure was positively associated with SSB intake (39, 40). Given the growing data on children with mental health problems, there is an urgent need to fully identify underlying dietary intake problems, which may not only exacerbate these problems but may also contribute to physical health problems later in life for these growing children. Despite this evidence, the effects of other common diet components, such as fats and sugar, on mental health are still unclear. Furthermore, to our knowledge, few previous studies have analyzed the association between takeaway patterns, SSBs, and psychological behavioral problems among children and adolescents, and few have been about the interactive effect of this association. Based on the results of the reviews mentioned above that fast-food

consumption and carbonated soft drink consumption in children and adolescents tend to co-occur, we hypothesized that there might be interactive effects of takeaway patterns and SSBs in the psychological behavioral problems among children and adolescents. In addition, our study explored multiple types of sugary drinks. In this study, we used data of cross-sectional investigation from China to analyze the interactive model. Therefore, our study aimed to investigate the individual and interactive relationships between SSBs, takeaway dietary pattern, and psychological and behavioral problems (PBPs) among Chinese children and adolescents.

METHODS

Study Designs

We took into account both the sampling method and the partnership. We first contacted the Centers for Disease Control and Prevention (CDC) in Bao'an District of Shenzhen, and the local CDC finally selected six streets according to the geographical distribution and the degree of school cooperation. Fourteen schools were selected randomly. A total of 33,801 primary, junior, and senior high school students (mean age = 12.44, SD = 3.47) ranging from 6 to 18 years old were recruited in this study using a health survey of children and adolescents in junior and senior high schools (grades 1–12). In each school, a cluster sampling method was used to extract three classes from each grade. The participants were then asked to complete a questionnaire. Written informed consent and questionnaires were obtained from the students (grades 5–12) or their parents (grades 1–4) (one for parents (grades 1–4) and one for self-reporting (grades 5–12), so the grade 1–4 children obtained their consent from their parents, and consent from grade 5–12 students was obtained directly from them). There were two types of questionnaires: one for parents (grades 1–4) and one for self-reporting (grades 5–12). The survey was conducted from April to May 2019. Due to an unwillingness to respond to the questionnaire, absence from school, high levels of missing data (a questionnaire with missing value >5%), or obviously fictitious responses, 3,613 (10.7%) participants were excluded from the study. Thus, the data from 30,188 participants (response rate: 89.3%) were analyzed. This sample is well-represented in the general population of China, as it also involves almost all children's and adolescents' age groups, including primary, junior, and senior high school samples. This study was approved by the Ethics Committee of Anhui Medical University.

Measures

We conducted a comprehensive questionnaire to measure some variables, including SSB intake, fast-food/takeaway consumption assessment of psychological behavioral problems, and demographic variables. Participants filled out questionnaires in separate classrooms where privacy was guaranteed. During the investigation, two or three investigators in each room provided technical support. The assessment of psychological behavioral problems was performed through the Strengths and Difficulties Questionnaire (SDQ) content on the questionnaire. SDQ includes 25 items, including hyperactivity problems,

emotional symptoms, conduct problems, peer problems, and prosocial problems (41). The SDQ is a short screening instrument that addresses the positive and negative behavioral attributes of children and adolescents; the SDQ is widely used to evaluate child developmental disabilities, and psychological and psychiatric conditions or disorders (42); and SDQ scales have been used as a tool in various studies for child mental health and validated for internal consistency (43). Children's responses can be categorized as normal, borderline, or abnormal for each of the subscales. Total difficulties of SDQ scores above the 90th percentile were classified as abnormal; the 80th to 90th percentiles were classified as "borderline," and those below the 80th percentile were classified as "normal" (44). The internal consistency of the SDQ total score was good (Cronbach's alpha 0.762) in our manuscript.

The frequency of carbonated, soda, tea and milk beverage, fruit and vegetable juice drinks, coffee drinks and energy drinks, and vegetable protein drink consumption has used in the questionnaire to figure out the total scores (45). Low SSB intake was defined as the lowest quintile (≤ 20 th percentile) of the total score of SSBs serving equivalents per week; medium SSB intake was defined as the second to fourth quintiles (> 20 th to < 80 th percentile); and high SSB intake was defined as the highest quintile (≥ 80 th percentile) (46). In our study, takeaway dietary pattern mainly refers to the takeaway behavior. Students were asked by one question: "How many times do you eat takeaways each week? (37)". The frequency answers were never, one to two times, three to four times, and more than five times. The frequency was categorized as never, low frequency, medium frequency, and high frequency.

Statistical Analysis

The database was created by EpiData 3.0. Statistical analyses were performed with SPSS 23.0 and GraphPad Prism. Descriptive analyses were used to show demographic information of the sample. Pearson's chi-squared tests were performed to test the prevalence of PBPs. Additionally, the dose-response trend test was conducted in the one-way analysis of variance. Multivariable logistic regression was used to explore the independent and interactive associations of takeaways, SSBs, and PBPs. GraphPad Prism was used to draw the correlation graphs. Models controlled for age, gender, grade, residential areas, family economic level, and parents' educational level. Odds ratios (ORs) and their 95% confidence intervals (CIs) were calculated. The significance level was set at $p < 0.05$.

RESULTS

Participants

We first arranged staff to input the questionnaires, and then data were imported into SPSS. Questionnaires with missing values >5% were deleted. Then we use multiple imputation to fill in data with missing values <5%. In total, 33,801 students consented to participate and have completed the questionnaire. Excluding participants whose data were incomplete and did not meet the criteria (excluding questionnaires with a missing value of >5%), the final study had 30,188 participants. The sample's mean age

TABLE 1 | General characteristics of the samples, *n* (%).

Variables	Total	Male	Female	χ^2
Age (years)				
≤12	14,484 (48.0)	8,127 (48.1)	6,357 (47.8)	0.21
>12	15,704 (52.0)	8,770 (51.9)	6,934 (52.2)	
Grade				
Primary	13,420 (44.5)	7,544 (44.6)	5,876 (44.2)	0.58
Junior high	8,232 (27.3)	4,590 (27.2)	3,642 (27.4)	
Senior high	8,536 (28.3)	4,763 (28.2)	3,773 (28.4)	
Academic record				
Good	7,580 (25.1)	4,246 (25.1)	3,334 (25.1)	73.65**
Medium	17,573 (58.2)	9,567 (56.6)	8,006 (60.2)	
Bad	5,035 (16.7)	3,084 (18.3)	1,951 (14.7)	
Residential areas				
Country	5,585 (18.5)	3,254 (19.3)	2,331 (17.6)	16.88**
Town	2,754 (9.1)	1,490 (8.8)	1,264 (9.5)	
City	21,849 (72.4)	12,153 (71.9)	9,696 (72.9)	
Father's education				
Junior high or lower	9,461 (31.9)	5,574 (33.0)	4,067 (30.6)	22.79**
Senior high	11,387 (37.7)	6,339 (37.5)	5,048 (38.0)	
Junior college or above	9,160 (30.3)	4,984 (29.5)	4,176 (31.4)	
Mother's education				
Junior high or lower	12,203 (40.5)	6,992 (41.4)	5,211 (39.2)	14.70**
Senior high	11,184 (37.0)	6,170 (36.5)	5,014 (37.7)	
Junior college or above	6,801 (22.5)	3,735 (22.1)	3,066 (23.1)	
Family economic level				
Under moderate	4,113 (13.6)	2,596 (15.4)	1,517 (11.4)	100.22**
Moderate	20,395 (67.6)	11,144 (66.0)	9,251 (69.6)	
Over moderate	5,680 (18.8)	3,157 (18.7)	2,523 (19.0)	
SSB frequency				
High intake	6,482 (21.5)	4,290 (25.4)	2,192 (16.5)	358.88**
Medium intake	15,623 (51.8)	8,421 (49.8)	7,202 (54.2)	
Low intake	8,083 (26.8)	4,186 (24.8)	3,897 (29.3)	
Takeaway frequency				
Never	17,183 (56.9)	9,788 (57.9)	7,395 (55.6)	26.86**
Low frequency	11,426 (37.8)	6,216 (36.8)	5,210 (39.2)	
Medium frequency	1,126 (3.7)	611 (3.6)	515 (3.9)	
High frequency	453 (1.5)	282 (1.7)	171 (1.3)	

SSB, sugar-sweetened beverage.

* $p < 0.05$; ** $p < 0.01$.

was 12.44 years ($SD = 3.47$). There were 13,291 (44.0%) girls and 16,897 (56.0%) boys. The primary participants were 44.5%. There were no association between gender, age, and grade. Females were more likely to have SSBs and takeaway consumption. The characteristics of the participants' demographics are shown in Table 1.

Sugar-Sweetened Beverages, Takeaway, and Psychological and Behavioral Problem Symptoms (Strengths and Difficulties Questionnaire Scores)

The top three SSBs in the intake frequency were milk beverages drinks (not milk), vegetable protein drinks, and

TABLE 2 | The gender difference of SDQ scores among the samples, *n* (%).

Variables	Total	Male	Female	χ^2
Hyperactivity problems				
Normal	23,139 (76.6)	12,621 (74.7)	10,518 (79.1)	89.34**
Borderline	3,109 (10.3)	1,830 (10.8)	1,279 (9.6)	
Abnormal	3,940 (13.1)	2,446 (14.5)	1,494 (11.2)	
Emotional symptoms				
Normal	21,499 (71.2)	12,698 (75.1)	8,801 (66.2)	325.21**
Borderline	3,103 (10.3)	1,632 (9.7)	1,471 (11.1)	
Abnormal	5,586 (18.5)	2,567 (15.2)	3,019 (22.7)	
Conduct problems				
Normal	25,663 (85.0)	14,026 (83.0)	11,637 (87.6)	130.25**
Borderline	2,439 (8.1)	1,496 (8.9)	943 (7.1)	
Abnormal	2,086 (6.9)	1,375 (8.1)	711 (5.3)	
Peer problems				
Normal	25,431 (84.2)	13,934 (82.5)	11,497 (86.5)	
Borderline	2,822 (9.3)	1,754 (10.4)	1,068 (8.0)	91.42**
Abnormal	1,935 (6.4)	1,209 (7.2)	726 (5.5)	
Prosocial problems				
Normal	22,030 (73.0)	11,836 (70.0)	10,194 (76.7)	
Borderline	4,929 (16.3)	2,936 (17.4)	1,993 (15.0)	197.71**
Abnormal	3,229 (10.7)	2,125 (12.6)	1,104 (8.3)	
Total difficulties				
Normal	24,216 (80.2)	13,599 (80.5)	10,617 (79.9)	
Borderline	3,327 (11.0)	1,869 (11.1)	1,458 (11.0)	4.46
Abnormal	2,645 (8.8)	1,429 (8.5)	1,216 (9.1)	

SDQ, Strengths and Difficulties Questionnaire.

* $p < 0.05$; ** $p < 0.01$.

fruit and vegetable juice drinks. Intake of milk beverages drinks accounted for the largest proportion, while the intake frequency of vegetable protein drinks was more than twice as much as fruit and vegetable juice drinks across the overall intake frequency groups; soda drinks and energy drinks were the least frequent. In our results, 56.9, 37.8, 3.7, and 1.5% of adolescents' takeaway dietary pattern was never, high frequency, medium frequency, and low frequency. And females were more likely to report emotional symptoms. In addition, high SSBs and takeaway consumption were associated with hyperactivity problems, emotional symptoms, conduct problems, peer problems, prosocial problems, and total difficulties. Other findings are shown in Tables 2, 3.

The Relationship Between Sugar-Sweetened Beverages, Takeaway, and Psychological and Behavioral Problems

In Table 4, after gender, grade, residential area, academic record, parents' educational level, and self-reported family economic level were adjusted for, more frequent intake of SSBs ($OR = 2.23$, $95\%CI = 2.0-2.47$, $p < 0.01$) and higher takeaway consumption ($OR = 1.81$, $95\%CI = 1.66-1.97$, $p < 0.01$) were associated with higher SDQ total difficulties scales. The same results about SSB consumption were also found in emotional symptoms (OR

TABLE 3 | Scores on SDQ total difficulties and subscales, among sugar-sweetened beverages and takeaway.

	Total difficulties	Emotional symptoms	Conduct problems	Hyperactivity problems	Peer problems	Prosocial problems
SSBs						
High intake	19.40 ± 5.29	2.91 ± 2.33	2.38 ± 1.63	4.02 ± 2.11	3.15 ± 1.60	6.94 ± 2.11
Medium intake	18.30 ± 4.86	2.52 ± 2.18	1.99 ± 1.44	3.97 ± 2.19	2.88 ± 1.59	6.94 ± 2.06
Low intake	17.63 ± 4.89	2.16 ± 2.09	1.81 ± 1.42	3.98 ± 2.28	2.75 ± 1.64	6.93 ± 2.09
p-value	<0.01	<0.01	<0.01	<0.01	<0.01	0.038
Takeaway						
Never	18.06 ± 4.94	2.34 ± 2.14	1.94 ± 1.47	3.91 ± 2.23	2.89 ± 1.63	6.98 ± 2.08
Low frequency	18.57 ± 4.97	2.64 ± 2.23	2.07 ± 1.46	4.05 ± 2.14	2.90 ± 1.56	6.91 ± 2.04
Medium frequency	19.93 ± 5.34	3.24 ± 2.43	2.50 ± 1.65	4.33 ± 2.14	3.09 ± 1.65	6.76 ± 2.11
High frequency	20.48 ± 5.78	3.40 ± 2.59	2.80 ± 1.88	4.44 ± 2.18	3.36 ± 1.86	6.49 ± 2.49
p-value	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01

SDQ, Strengths and Difficulties Questionnaire; SSB, sugar-sweetened beverage.

* $p < 0.05$; ** $p < 0.01$.

TABLE 4 | Individual effects of sugar-sweetened beverages (SSBs) and takeaway patterns on psychological and behavioral problems.

	SSBs (reference group: low SSB intake)		Takeaway pattern (reference group: never)		
	Medium	High	High	Medium	Low
Hyperactivity problems (reference group: normal)					
Borderline	1.03 (0.94–1.12)	1.02 (0.94–1.10)	1.70 (1.30–2.23)**	1.35 (1.11–1.64)*	1.16 (1.07–1.25)*
Abnormal	1.27 (1.14–1.41)**	1.03 (0.93–1.14)	1.40 (1.07–1.83)*	1.51 (1.27–1.79)**	1.07 (0.99–1.15)
Emotional symptoms (reference group: normal)					
Borderline	1.20 (1.10–1.31)**	1.30 (1.21–1.42)**	1.69 (1.26–2.27)*	1.61 (1.33–1.95)**	1.23 (1.14–1.33)**
Abnormal	1.39 (1.25–1.54)**	1.73 (1.60–1.87)**	2.51 (2.03–3.10)**	2.26 (1.96–2.60)**	1.27 (1.19–1.35)**
Conduct problems (reference group: normal)					
Borderline	1.28 (1.15–1.42)**	1.73 (1.53–1.96)**	2.17 (1.64–2.86)**	1.86 (1.54–2.25)**	1.14 (1.04–1.24)**
Abnormal	1.25 (1.10–1.41)**	2.31 (2.02–2.64)**	2.82 (2.17–3.66)**	2.14 (1.77–2.58)	1.04 (0.94–1.14)
Peer problems (reference group: normal)					
Borderline	1.02 (0.92–1.12)**	1.15 (1.09–1.22)**	1.65 (1.25–2.17)**	1.34 (1.11–1.62)**	1.01 (0.93–1.09)
Abnormal	0.98 (0.87–1.09)	1.27 (1.14–1.43)**	1.84 (1.37–2.47)**	1.04 (0.83–1.32)	0.80 (0.72–0.88)**
Prosocial problems (reference group: normal)					
Borderline	0.92 (0.84–1.0)	1.12 (1.04–1.20)**	1.31 (1.02–1.68)*	1.31 (1.53–2.14)**	1.05 (0.97–1.13)
Abnormal	1.02 (0.92–1.14)	1.11 (1.01–1.21)*	2.34 (1.81–3.03)**	1.88 (1.56–2.26)**	1.16 (1.06–1.26)**
Total difficulties (reference group: normal)					
Borderline	1.15 (1.06–1.26)**	1.59 (1.44–1.75)**	1.53 (1.17–2.01)**	1.80 (1.53–2.14)**	1.05 (0.97–1.13)
Abnormal	1.38 (1.26–1.52)**	2.23 (2.00–2.47)**	2.34 (1.81–3.03)**	1.88 (1.56–2.26)**	1.16 (1.06–1.26)**

The model was controlled for age, gender, grade, residential areas, academic record, family economic level, and parents' education level.

* $p < 0.05$; ** $p < 0.01$.

= 1.73, 95%CI = 1.60–1.87, $p < 0.01$), conduct problems (OR = 2.24, 95%CI = 2.05–2.44, $p < 0.01$), peer problems (OR = 1.67, 95%CI = 1.55–1.80, $p < 0.01$), and prosocial problems (OR = 1.11, 95%CI = 1.01–1.21, $p < 0.01$), except for hyperactivity problems (OR = 1.03, 95%CI = 0.93–1.14). In addition, higher takeaway consumption was also associated with higher SDQ scales. These results are shown in **Table 4**. Results from multivariate logistic regression analysis indicated that both takeaway dietary pattern and SSBs are independently associated

with SDQ scores. Besides, they had a multiplied interaction impact between SSBs and takeaway dietary pattern on SDQ scores. Higher SSBs were more associated with total difficulties (OR = 3.10, 95%CI = 2.67–3.59, $p < 0.01$), emotional symptoms (OR = 2.10, 95%CI = 1.86–2.36, $p < 0.01$), conduct problems (OR = 3.24, 95%CI = 2.86–3.65, $p < 0.01$), peer problems (OR = 1.89, 95%CI = 1.69–2.12, $p < 0.01$), prosocial problems (OR = 1.26, 95%CI = 1.07–1.47, $p < 0.01$), hyperactivity problems (OR = 1.33, 95%CI = 1.15–1.55, $p < 0.01$), and higher takeaway

dietary pattern than low and medium SSB consumption. These results are shown in **Figure 1**.

DISCUSSION

Our study demonstrated the correlations between SSBs, takeaway dietary pattern, and PBPs in Chinese children and adolescents. After gender, age, family economic level, parents' education level and academic record, and residential area were adjusted for, SSBs and takeaway eating patterns were found to have individual and interactive effects on PBPs. In consideration of the discrepancies in unhealthy eating patterns for emotional and behavioral problems between Asians and other ethnicities, the results of this study may help us explore the influence of SSBs and takeaways on psychological behavioral problems in eastern dietary patterns.

Demographic characteristics and conditions known or considered to be correlates of psychological behavioral problems were measured; the consumption of SSBs, takeaways consumption, and psychological behavioral problems both associated with a variety of sociodemographic characteristics, which may confound the essential association between SSBs, takeaway consumption, and psychological behavioral problems (45). Children and adolescents with lower economic levels were at risk for poor diet status, for example, lower intake of fruits and vegetables, and higher intake of unhealthy snacks, fast food, and SSBs. A possible explanation was that the relative low prices on SSBs could explain why lower economic levels were associated with higher SSB intake, and lower economic levels were not enough for healthy dietary. Others include gender, parents' educational levels, age, and grade. This might imply that adolescents' personal economic levels should be included in the studies of health-related behaviors. So we determined the selection of covariates by referring to previous studies and literatures, as well as the preliminary experimental results of the research group (37). In addition, gender and age effects differ in behavioral and emotional problems. Gender differences were found in the distribution of PBPs. Compared with girls, boys were more likely to score higher conduct problems, peer problems, hyperactivity problems, prosocial problems, and total difficulties. These results were similar to previous studies (47–49). In terms of emotional problems, girls are more likely to have higher score than boys (47, 48). Similarly, children and adolescents with low family income, compared with high family income, were more likely to report PBPs; and those with low parental education were also more likely to have PBPs than those with high parental education. Our study revealed that SSB consumption and takeaway dietary pattern brought an individual and interactive relationship risk of PBPs after adjustments for confounders.

SSBs have been found to be associated with a higher prevalence of mental health problems (15, 19, 32). The most consumed non-alcoholic beverages were SSBs, coffee, and tea and may have important health consequences; others such as energy drinks also have same results (50). Schwartz et al. conducted a survey of 1,649 U.S. children about the Health Behavior Survey

and Hyperactivity Disorder questionnaire and found that higher SSB intake was associated with an increased risk of ADHD (22). This is similar to Alsamghan's result: a significance association was found with risk of hyperactivity/inattention who consumed energy drinks (51). More important, some of the bad behaviors established in childhood, such as the SSB eating pattern, may persist into adulthood (52, 53). Considering that students spend most of their time in school, the type of food sold or served in schools is an important environmental factor affecting children's eating patterns, and governments should restrict SSB provision in schools to promote healthy eating behavior among young people (54), so it is important for school leaders to take action to prevent adolescents' SSBs and takeaway dietary consumption. The results should catch the attention from not only parents and policymakers but also the producers and sellers of SSBs. In our study, we have not found a relationship between SSB consumption and hyperactivity problems. One possible reason was that our SSB scores included numerous varieties; some of these beverages were positively correlated with hyperactivity and prosocial problems, while others were negatively correlated, so there might be an offsetting effect.

The PBP consequences of SSBs can be summarized as follows: a) sugar intolerance (physical discomfort after eating or drinking sugary foods); b) body's reactive hypoglycemia after ingestion; and c) decrease in intake of essential micronutrients. We extracted some of the more important results: if psychological problems are not paid attention to, these can easily lead to depression and mental disorders. So how are sugary drinks related to depression and mental disorders? Some researches have verified their correlated mechanisms. Continual consumption of SSBs, especially diet SSBs, may increase the risk of depression, while coffee consumption may reduce the risk. We hypothesized that there are several possible mechanisms linking sugar intake and anxiety/depression, including oxidative stress response (55) and serotonin (5-HT) mechanisms (56). Other researches have discussed the connection between high sugary behavior and mental health, including high-sensitivity C-reactive protein (hsCRP) (57, 58). Other studies demonstrated that the consumption of sodium benzoate (found in beverages) impairing memory and motor coordination, reducing glutathione, increasing the malondialdehyde level in the brain, and inducing ADHD in children is emphasized (59). In Yu's study, compared with those who did not consume SSBs, children who consumed SSBs at moderate levels and high levels were associated with having ADHD (60); and another study conducted by Howard revealed that an "unhealthy," western-style preference diet (i.e., more meat and sweets and fewer vegetables and fruits) was associated with ADHD (61).

The theory of planned behavior (TPB) states that SSB intake causes not only PBPs but also a range of behaviors (62) and that they influence one other (31, 63). Experimental results showed that more frequent intake of SSBs was associated with higher prevalence of middle and lower annual household income, lower frequency of physical activity, more takeaway dietary behavior, more fast-food behavior, and more frequency of screen time. And the results from the human sample show the same result of sensitivity to reward and adolescents' unhealthy

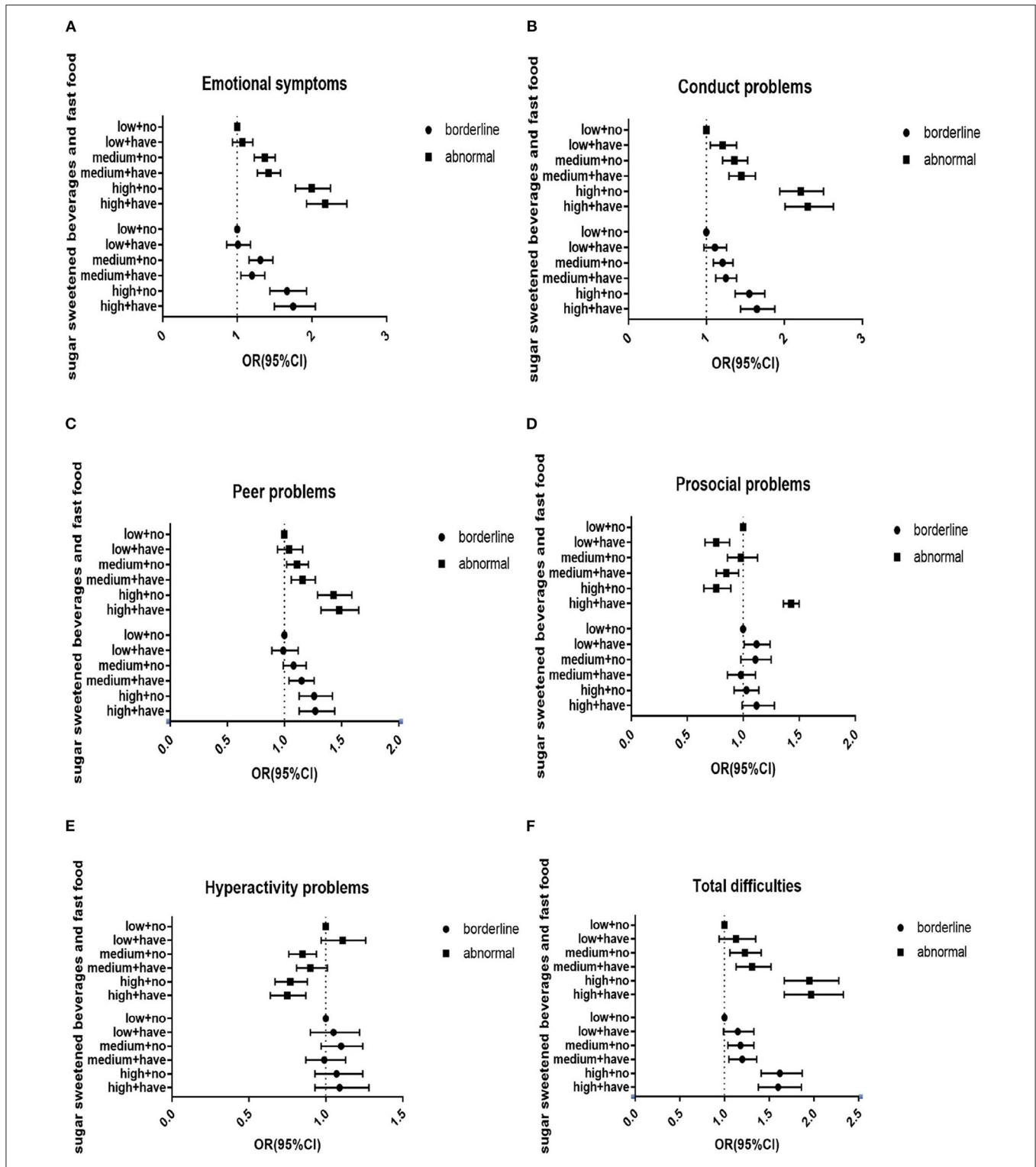


FIGURE 1 | Interactive effects of sugar-sweetened beverages and takeaway pattern on psychological and behavioral problems among Chinese children and adolescents. **(A)** Interactive effects of sugar-sweetened beverages and takeaway pattern on emotional symptoms. **(B)** Interactive effects of sugar-sweetened beverages and takeaway pattern on conduct problems. **(C)** Interactive effects of sugar-sweetened beverages and takeaway pattern on peer problems. **(D)** Interactive effects of sugar-sweetened beverages and takeaway pattern on prosocial problems. **(E)** Interactive effects of sugar-sweetened beverages and takeaway pattern on hyperactivity problems. **(F)** Interactive effects of sugar-sweetened beverages and takeaway pattern on total difficulties. Low, low SSB intake; Medium, medium SSB intake; High, high SSB intake; Have, have takeaway consumption; No, no takeaway consumption. The model was controlled for age, gender, grade, residential areas, academic record, family economic level, and parents' education level. **p* < 0.05; ***p* < 0.01.

snacking and drinking behaviors (64). So we also proposed the takeaway dietary pattern and found that takeaway dietary pattern was correlated with PBPs. Our results further suggest that psycho-pathological symptoms, including emotional, conduct and prosocial problems, were significantly associated with SSB consumption and takeaway dietary pattern in a dose-dependent manner. Specifically, after variables were controlled for, takeaway and SSB eating patterns are associated with increased risk of psycho-pathological symptoms; these results were consistent with previous cross-sectional studies (29, 65). One possible reason is that people find healthier foods to be tastier and more popular than unhealthy foods (66).

We found an obvious interaction between high SSBs and takeaway dietary pattern on PBPs. High SSB intake causes an increase in the risk of PBPs in students with high takeaway dietary pattern compared with students with low takeaway dietary pattern. The possible underlying mechanisms for this interaction are complex. One possible reason was de Bruijn's research: TPB also means that health behaviors in youth tend to cluster and that interventions that succeed in inducing positive changes in cognition and intention in a behavior may lead to positive changes in an aggregation behavior (62). Another possible reason was a positive correlation between SSBs and takeaway diet pattern (67). Higher takeaway dietary pattern was associated with higher SSB consumption (63). The unhealthy association is thought to be caused by high exposure to food and drink advertisements during screen time. Unhealthy home food availability increased takeaway diet pattern, further influencing the consumption of SSBs (68). Because when some take the takeaway diet pattern, they do not notice what they were eating, which could eventually lead to overconsumption (69). So we could think of the interactive correlation between SSBs and UDP on PBPs (37).

Our study has several limitations. First, this study is cross-sectional research; it cannot detect a causal relationship and could not judge causality or direction, and a future longitudinal study is suggested. Second, SSBs and takeaway consumption were acquired through self-reporting, which may have caused recall bias. Third, there were many factors influencing PBPs, and we only have explored two of them, so further researches will pay attention to other factors. Despite these limitations, our research has some strengths. First, most importantly, this is a survey of Chinese children and adolescents, and the results of our study can be applied to public health and clinical practice in other populations. The limitations of other reports were the small sample sizes. Our research aims to explore the mental health behavioral problems of children and adolescents through a large sample and multi-age perspectives. In addition, 30,188

adolescents were sampled from 14 schools in Shenzhen, China, with a wide sampling range and a large sample size. The cluster stratified random sampling method was used to identify the sample, and primary schools, as well as middle schools, were included in this multilevel survey. These data were somewhat representative. We also analyzed several potential confounders. In this study, we analyzed the interactive effect to explore the correlation between SSBs, takeaway consumption, and PBPs, further demonstrating that we should pay close attention to the factors influencing children's and adolescents' mental health. Our study can also provide a good theoretical basis for the follow-up large sample of children and adolescents regarding SSBs, takeaway food, and mental health issues.

In summary, this study offers discernment into the association between SSB consumption, takeaway consumption, and PBPs among Chinese children and adolescents. Our results suggested that higher SSB consumption and higher takeaway consumption were all positively associated with PBPs. Also, the interactive relationship between SSBs and takeaway consumption was stronger than SSB consumption and takeaway consumption individually. This is a public health issue that cannot be ignored, given China's large population base and the growing trend of SSB consumption and takeaway consumption.

DATA AVAILABILITY STATEMENT

The datasets generated for this study are available on request to the corresponding author.

ETHICS STATEMENT

The studies involving human participants were reviewed and approved by the Ethics Committee of Anhui Medical University. Written informed consent to participate in this study was provided by the participants' legal guardian/next of kin.

AUTHOR CONTRIBUTIONS

FT designed the study. YZ, XW, ST, QW, RW, TL, and QZ performed the survey research. YZ, XW, ST, and QW analyzed the data. YZ drafted the manuscript. All authors read and approval the final manuscript.

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